PhytoKeys 175: 1–11 (2021)
doi: 10.3897/phytokeys.175.61044
https://phytokeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
PhytoKeys
Launched to accelerate biodiversity research

# *Encyonopsis indonesica* sp. nov. (Bacillariophyceae, Cymbellales), a new diatom from the ancient lake Matano (Sulawesi, Indonesia)

Dmitry A. Kapustin[1], Anton M. Glushchenko[1], John P. Kociolek[2,3], Maxim S. Kulikovskiy[1]

**1** *Timiryazev Institute of Plant Physiology, Russian Academy of Sciences, 127276, Moscow, Russia* **2** *Museum of Natural History, Boulder, Colorado, 80309, USA* **3** *Department of Ecology and Evolutionary Biology University of Colorado, Boulder, Colorado, 80309, USA*

Corresponding author: Dmitry A. Kapustin (dima_kapustin@outlook.com)

Academic editor: K. Manoylov | Received 23 November 2020 | Accepted 24 February 2021 | Published 17 March 2021

**Citation:** Kapustin DA, Glushchenko AM, Kociolek JP, Kulikovskiy MS (2021) *Encyonopsis indonesica* sp. nov. (Bacillariophyceae, Cymbellales), a new diatom from the ancient lake Matano (Sulawesi, Indonesia). PhytoKeys 175: 1–11. https://doi.org/10.3897/phytokeys.175.61044

## Abstract

A new species, *Encyonopsis indonesica*, is described from the ancient lake Matano, Sulawesi island, Indonesia. The morphology of this species was studied by means of light and scanning electron microscopy. *E. indonesica* has a remarkable valve ultrastructure. The valve surface is ornamented with numerous longitudinal siliceous ribs and siliceous verrucae. Valve face delineated from the mantle by a thickened marginal ridge. Raised sterna border the raphe branches. Raphe is distinctly undulate with distal ends hooked strongly to the ventral side. The only similar species to *E. indonesica* is *Amphora dissimilis* described from New Caledonia. Comparison of both taxa is given and *A. dissimilis* is transferred to *Encyonopsis*. The taxonomic placement of both taxa is evaluated, and the phenomenon of external siliceous ornamentation is discussed.

## Keywords

ancient lake, diatoms, Indonesia, morphology, SEM, taxonomy

Copyright *Dmitry A. Kapustin et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

## Introduction

The genus *Encyonopsis* Krammer was established during a comprehensive revision of cymbelloid diatoms by Krammer (1997a). It differs from morphologically related genus *Encyonema* Kützing mainly by its slightly dorsiventral valve outline and by terminal raphe fissures only slightly bent to the ventral margin (Krammer 1997a, b; Potapova 2014). Though described less than a quarter of a century ago, over 170 taxa have been assigned to *Encyonopsis* (Kociolek et al. 2020). Many taxa were transferred by Krammer (1997b) from other genera in his initial circumscription of the genus, but since then new species of the genus have been described from western North America (Bahls 2013; Graeff and Kociolek 2013; Kociolek et al. 2014; Mark et al. 2019), Central America (Wydrzycka and Lange-Bertalot 2001), South America (Metzeltin and Lange-Bertalot 2007; Wengrat et al. 2015), Europe (Van de Vijver et al. 2012; Kennedy et al. 2019), Asia (Krammer 2003; Potapova et al. 2014), Madagascar (Metzeltin and Lange-Bertalot 2002), and Reunion Island (Le Cohu et al. 2014).

Relatively recently the genus *Kurtkrammeria* Bahls (2015) was proposed, with most species of the genus having been transferred from *Encyonopsis*. This genus differs from *Encyonopsis* by having convergent striae at the apices, slit-like apically-oriented or crescent-shaped areolae, the internal proximal raphe ends hooked strongly towards the dorsal side of the valve and the presence (or absence) of stigmata (Bahls 2015; Marquardt et al. 2016; Zhang et al. 2020). Despite the rather weak differences, *Kurtkrammeria* is an accepted genus and several new species have been described since its description (Marquardt et al. 2016; Zhang et al. 2020). However, sometimes taxa of *Gomphonema* are misidentified as *Encyonopsis* or *Kurtkrammeria* (e.g., Bahls et al. 2018; Almeida et al. 2020), suggesting a review of the distinguishing features of these genera may be warranted.

The Malili lakes are located in the mountains of Central Sulawesi and are composed of five tectonic lakes, namely, Matano, Mahalona, Towuti, Lontoa (also known as Wawontoa) and Masapi (Brooks 1950; Vaillant et al. 2011; von Rintelen et al. 2012). Lake Matano is the oldest lake among them, and its estimated age is 2 to 4 million years old (Brooks 1950; Vaillant et al. 2011). The most extensive treatment on diatoms from the Malili lakes was performed by Hustedt (1942). Subsequently, many new taxa were described from these lakes (Bramburger et al. 2006; Kociolek et al. 2018; Kapustin et al. 2019) and some taxa were re-investigated (Kapustin et al. 2017; Kapustin and Kulikovskiy 2018; Kapustin et al. 2020; Kulikovskiy et al. 2020).

The aim of this paper is to describe a new *Encyonopsis* species based on light and scanning electron microscopy, detail its unusual morphology, and discuss its generic placement.

## Material and methods

An epilithic sample containing *Encyonopsis indonesica* was collected from Lake Matano in 2010 (02°28.433'S, 121°15.710'E). With a Hanna multiparameter probe meter

(HANNA HI98128), the temperature was recorded as 28.5 °C, pH as 8.53, and conductivity as 177 $\mu S \cdot cm^{-1}$.

The sample was heated in concentrated hydrogen peroxide (~37%) to dissolve the organic matter. It was then rinsed with deionized water four times at 12 h intervals. After decanting and filling with deionized water up to 100 ml, the suspension was spread on to coverslips and left to dry at room temperature. Permanent diatom slides were mounted in Naphrax. Light microscopic (LM) observations were performed with a Zeiss Scope A1 microscope equipped with an oil immersion objective (100×/n.a.1.4, differential interference contrast [DIC]) and Zeiss Axio-Cam ERc 5s camera. Valve ultrastructure was examined by means of a JSM-6510LV scanning electron microscope (Papanin Institute for Biology of Inland Waters RAS, Borok, Russia). For scanning electron microscopy (SEM), parts of the suspensions were fixed on aluminum stubs after air-drying. The stubs were sputter coated with 50 nm of gold.

## Results

**Class Bacillariophyceae Haeckel**
**Order Cymbellales D.G. Mann**
**Family Cymbellaceae Kützing**
**Genus *Encyonopsis* Krammer**

***Encyonopsis indonesica* Kapustin, Kulikovskiy & Kociolek, sp. nov.**
Figs 1–4

**Holotype** (here designated): MHA 01105. Fig. 1B illustrates the holotype.

**Type locality.** Indonesia, Island of Sulawesi, Lake Matano, 02°28.433'S, 121°15.710'E, *leg.* I.I. Ivanov, 14.XI.2010.

**Etymology.** The specific epithet refers to the type locality from Indonesia.

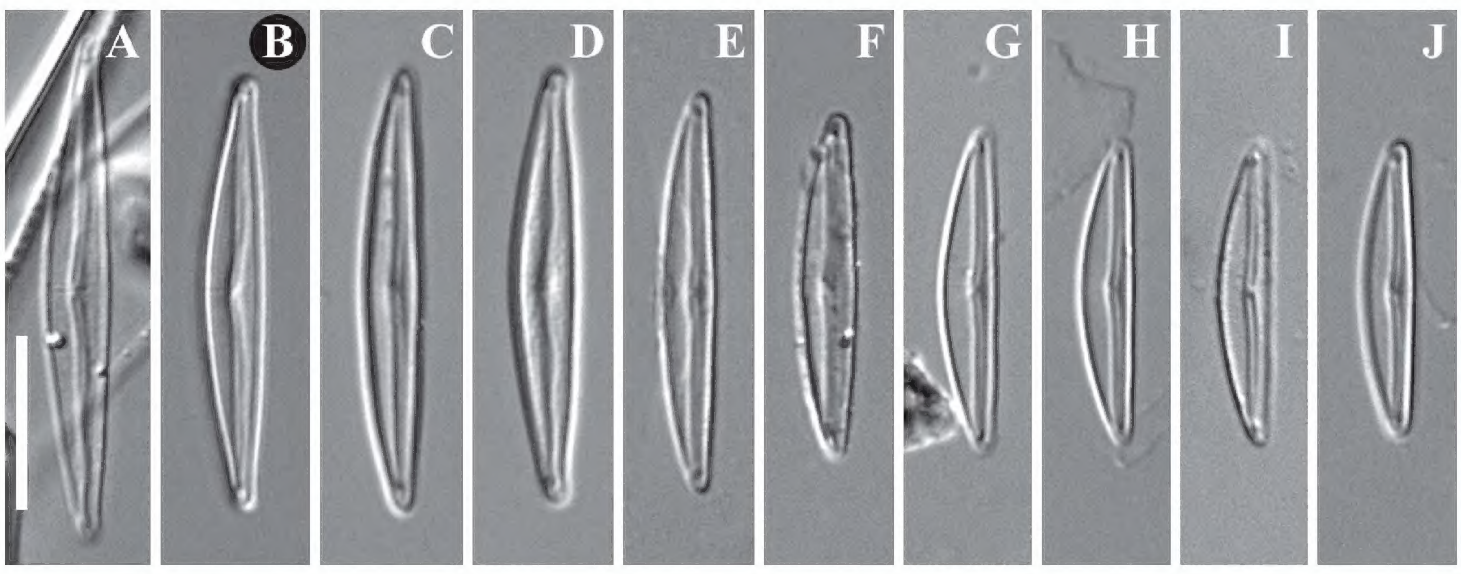


**Figure 1. A–J** *Encyonopsis indonesica* sp. nov. (LM). Size diminution series showing variation in valve outline **B** holotype specimen. Scale bar: 10 μm.

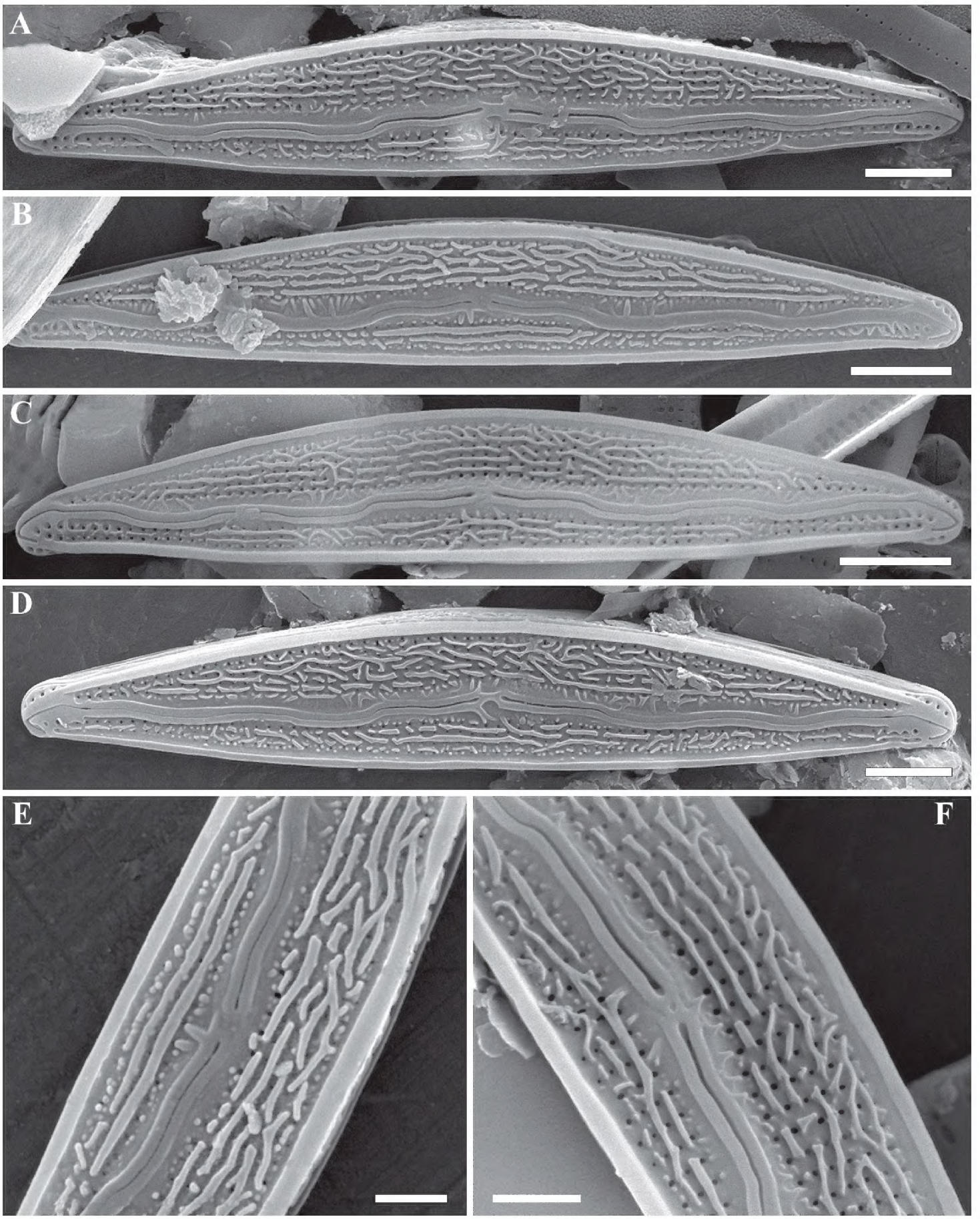


**Figure 2. A–F** *Encyonopsis indonesica* sp. nov. (SEM). External view **A–D** whole valves showing morphological variability in external ornamentation **E, F** central area with dorsally deflected proximal raphe ends. Note the thickened marginal ridge, longitudinal ribs and verrucae on the valve surface. Scale bars: 2 μm (**A, D**), 2.5 μm (**B, C**), 1 μm (**E, F**).

**Description. LM (Fig. 1A–J).** Valves dorsi-ventral, semi-lanceolate, with a slightly convex dorsal margin and a nearly straight ventral margin. Apices slightly protracted, cuneate to slightly rostrate. Axial area very narrow, following the course of the raphe

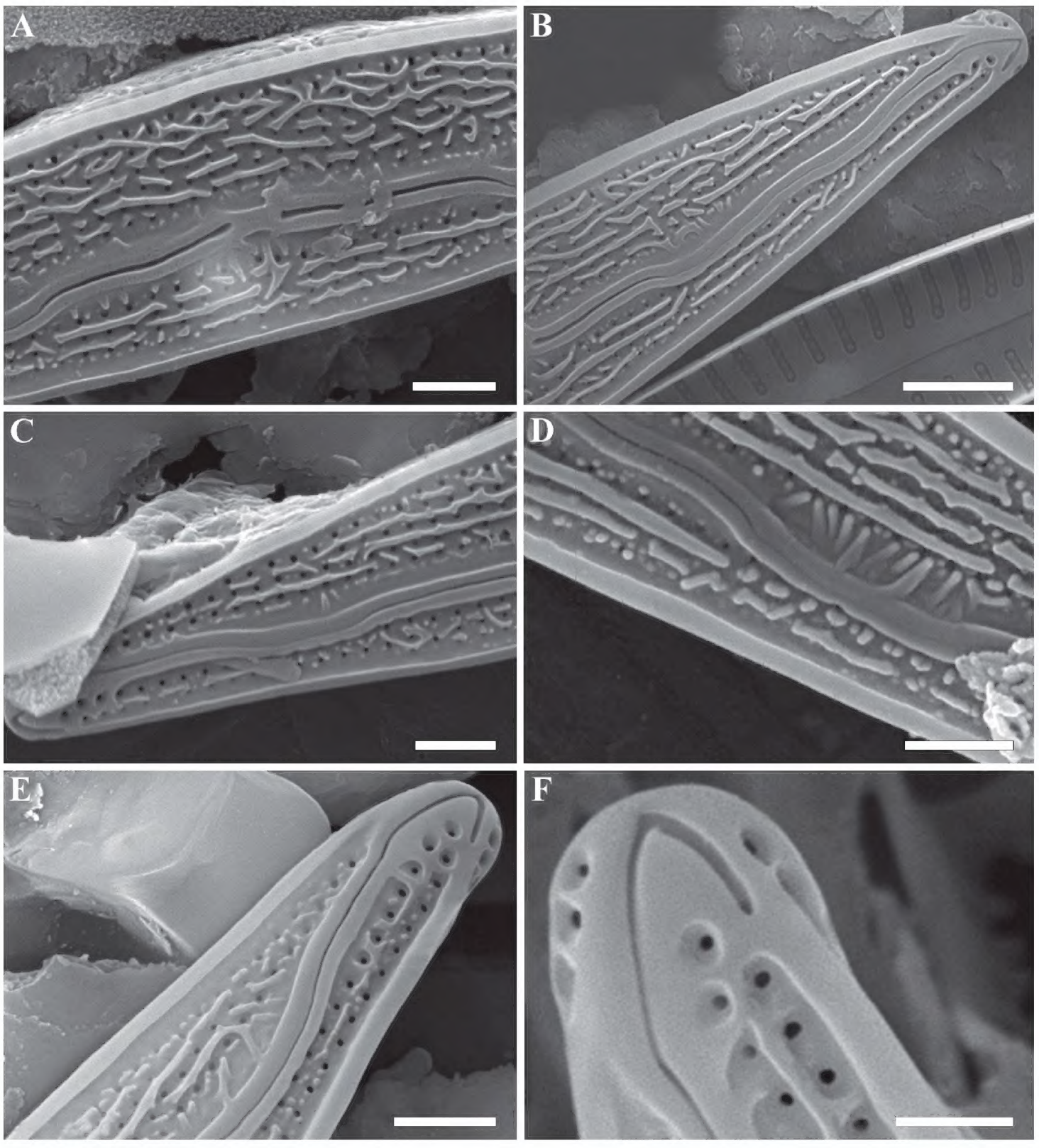


**Figure 3. A–F** *Encyonopsis indonesica* sp. nov. (SEM). External view **A** central area **B, C** valve ends. Note a hyaline area along the raised sternum **D** a part of a raphe with transapical ribs on the valve surface **E, F** valve ends with strongly hooked distal raphe fissures. Scale bars: 1 μm (**A, C, D, E**), 2 μm (**B**), 0.5 μm (**F**).

and central area not expressed. Raphe undulate. Striae indistinct in LM. Length 17–29 μm (21.9 ± 3.3; n = 16), breadth 3–4 μm (3.4 ± 0.3; n = 16), length/width ratio 5.7–7.4 (6.5 ± 0.6; n = 16).

**SEM (Figs 2–4).** External valve face occasionally covered with siliceous verrucae and numerous siliceous ribs of different lengths mostly aligned along the apical axis (Fig. 2A–F). Valve face delineated from the mantle by a thickened marginal ridge. Raphe distinctly undulate, with the proximal raphe ends deflected slightly towards the dorsal margin and the distal ends hooked strongly to the ventral side (Fig. 3E,

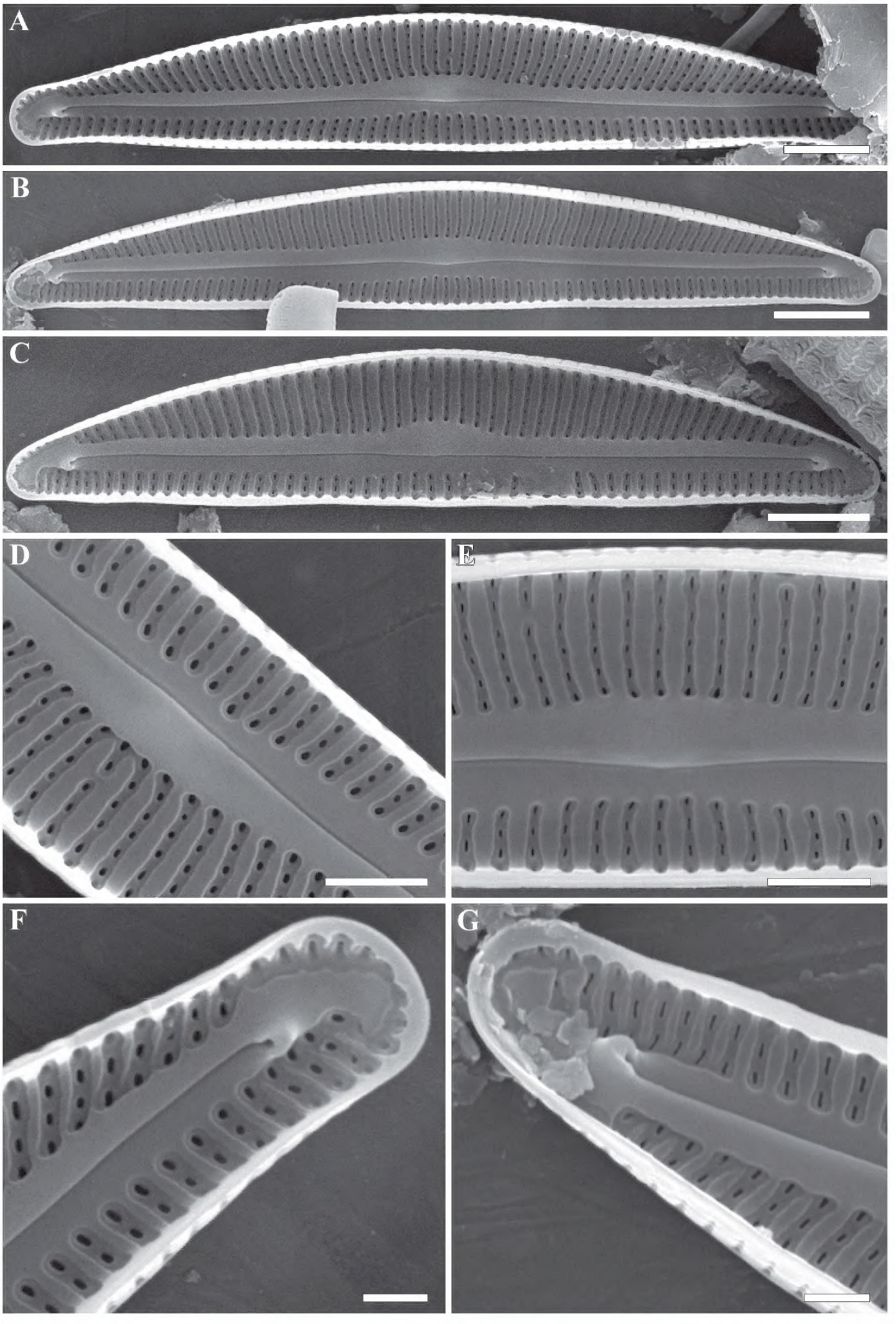


**Figure 4. A–G** *Encyonopsis indonesica* sp. nov. (SEM). Internal view **A–C** whole valve **D, E** central area with rounded or elongated areolae located in a transapically elongated grooves **F, G** valve ends with typical helictoglossa. Note a thin, plate-like silica thickening present between helictoglossa and apex. Scale bars: 2 μm (**A, C**), 2.5 μm (**B**), 1 μm (**D, E**), 0.5 μm (**F, G**).

F). Raised sterna border the raphe branches. Striae almost parallel at the valve center becoming weakly radiate towards the apices, 34–36 in 10 μm. Striae composed of 2–4 areolae on the ventral side and 5–6 areolae on the dorsal side. Areolae rounded and unoccluded, being occasionally slightly smaller near the valve margins, 50 in 10 μm. Internally, areolae rounded or transapically elongated located in a shallow groove. Internal proximal raphe ends obscured; distal raphe ends terminate in well-developed helictoglossae (Fig. 4A–E). A thin, plate-like silica thickening present between helictoglossa and apices (Fig. 4F, G).

## Discussion

*Encyonopsis indonesica* is very similar to *Amphora dissimilis* described from New Caledonia (Moser et al. 1998), however the latter is slightly larger (length 29–40 μm; breadth 4.6–5.4 μm) and has a more arched dorsal margin and more attenuated apices. Additionally, *E. indonesica* is more finely striated and has 34–36 striae in 10 μm whereas *A. dissimilis* has 18–20 striae in 10 μm, which are discernible under LM. External valve structure of both species looks very similar as well. The valve face is delineated from the mantle by a thickened marginal ridge. In *A. dissimilis* the valve face is more heavily silicified, the longitudinal siliceous ribs are longer and thicker (they are even discernible in LM) and they are present in smaller numbers than in *E. indonesica*. In *A. dissimilis* the raphe is almost straight and filiform. It is located close to the ventral side. At the valve center the raphe branches are abruptly curved dorsally to form an arc. Whereas in *E. indonesica* the raphe is distinctly undulate and does not form an arc at the valve center. Unfortunately, the internal valve structure of *A. dissimilis* remains unknown. Morphological and morphometric features of both species are summarized in Table 1.

The authors initially had some doubts when placing *Amphora dissimilis* in *Amphora* (Moser et al. 1998, pp. 90, 91). Levkov (2009) included this species in his monograph on *Amphora* but placed it with other species with uncertain systematic positions. He pointed out that the raphe system of *Amphora dissimilis* significantly differs from that of *Amphora* sensu stricto, however, he decided to keep this species in *Amphora* pending additional observations (Levkov 2009).

We agree that *Amphora dissimilis* does not belong to this genus. Taking into account the remarkably similar morphology between *Encyonopsis indonesica* and *Amphora dissimilis* we propose to transfer the latter species to *Encyonopsis*:

***Encyonopsis dissimilis* (Metzeltin & Krammer) Kapustin, Kulikovskiy & Kociolek, comb. nov.**

Basionym: *Amphora dissimilis* Metzeltin & Krammer in Moser et al. 1998. Biblioth. Diatomol. 38: 90, pl. 43: figs 1–8.

In terms of valve outline, the degree of asymmetry about the apical axis might suggest we assign *Encyonopsis indonesica* and *E. dissimilis* to *Cymbellopsis* Krammer rather

**Table 1.** Morphological and morphometric comparisons among *Encyonopsis indonesica* and *E. dissimilis*.

| Taxon | Valve shape | Valve / ends | Raphe | Valve length, µm | Valve width, µm | Striae in 10 µm | Areolae in 10 µm |
|---|---|---|---|---|---|---|---|
| *Encyonopsis indonesica* | semi-lanceolate | cuneate to rostrate | undulate | 17–29 | 3–4 | 34–36 | 50 |
| *Encyonopsis dissimilis* | semi-lanceolate | cuneate | filiform, proximal ends are abruptly curved dorsally to form an arc at the valve center | 29–40 | 4.6–5.4 | 18–20 | no data |

than to *Encyonopsis*. All species of the genus *Cymbellopsis* have distinctly dorsiventral valve outlines whereas the species of the genus *Encyonopsis* have only slightly dorsiventral valve outlines. However, in *Cymbellopsis* taxa possess an intermissio of Type 1, similar to what is seen in *Encyonema silesiacum* (Krammer 1997a). *Encyonopsis indonesica*, however, lacks an intermissio. Additionally, in *Cymbellopsis* the areolae are internally occluded with hymens whereas in *Encyonopsis indonesica* areolae are unoccluded. Moreover, internally *Encyonopsis indonesica* possesses typical *Encyonopsis* morphology. All described *Cymbellopsis* taxa are restricted to South America and Africa (Kociolek 2018).

Remarkably, many endemic diatoms from Lake Matano, e.g. *Celebesia distinguenda* (Hustedt) Kapustin, Kulikovskiy & Kociolek, *Cymbella eunotioformis* Kapustin, Kociolek & Kulikovskiy, *C. densigranulata* Kapustin, Kociolek & Kulikovskiy, *Gomphonema matanense* Kapustin, Kociolek & Kulikovskiy and *Encyonopsis indonesica* are additionally ornamented with siliceous outgrowths, ridges, granules, or spines (Kapustin et al. 2017, 2019; Kociolek et al. 2018). This situation was also shown for another cymbelloid taxon, in a species of *Delicatophycus* Wynne (Le Cohu et al. 2020) described from New Caledonia. Since silicification in diatoms is genetically encoded (e.g. Kröger 2007) and the ornamentation is rather stable and apparently does not vary significantly, it is possible this feature can be used for species delimitation.

## Acknowledgements

Authors are grateful to the staff of the Interlaboratory Centre of Electron Microscopy of the Papanin Institute for Biology of Inland Waters, RAS, for technical assistance. Publication is based on research carried out with financial support by Russian President Foundation (МД-1446.2020.4) and by framework of the state assignment (theme АААА–А19–119041190086–6) for finishing manuscript.

## References

Almeida FF, Ector L, Silva ES, Wetzel CE (2020) *Gomphonema frequentiformis* (Metzeltin & Krammer) comb. nov. (Bacillariophyta): Ecology and taxonomy of a Neotropical diatom. Phytotaxa 439: 265–275. https://doi.org/10.11646/phytotaxa.439.3.8

Bahls LL (2013) *Encyonopsis* (Bacillariophyta, Cymbellaceae) from western North America: 31 species from Alberta, Idaho, Montana, Oregon, South Dakota and Washington, incl. 17 species described as new. Northwestern Diatoms 5: 1–44.

Bahls LL (2015) *Kurtkrammeria*, a new genus of freshwater diatoms (Bacillariophyta, Cymbellaceae) separated from *Encyonopsis*. Nova Hedwigia 101(1–2): 165–190. https://doi.org/10.1127/nova_hedwigia/2015/0263

Bahls LL, Wetzel CE, Ector L (2018) Transfer of *Kurtkrammeria eileencoxiae* to the genus *Gomphonema* (Bacillariophyta, Gomphonemataceae). Notulae algarum 50: 1–4.

Bramburger AJ, Haffner GD, Hamilton PB, Hinz F, Hehanussa PE (2006) An examination of species within the genus *Surirella* from the Malili lakes, Sulawesi Island, Indonesia, with descriptions of 11 new taxa. Diatom Research 21(1): 1–56. https://doi.org/10.1080/0269249X.2006.9705650

Brooks JL (1950) Speciation in ancient lakes (concluded). The Quarterly Review of Biology 25(2): 131–176. https://doi.org/10.1086/397539

Graeff CL, Kociolek JP (2013) New or rare species of cymbelloid diatoms (Bacillariophyceae) from Colorado (USA). Nova Hedwigia 97(1): 87–116. https://doi.org/10.1127/0029-5035/2013/0106

Hustedt F (1942) Süßwasser-Diatomeen des indomalayischen Archipels und der Hawaii-Inseln. Internationale Revue der Gesamten Hydrobiologie und Hydrographie 42(1–3): 1–252. https://doi.org/10.1002/iroh.19420420102

Kapustin DA, Kulikovskiy MS (2018) Transfer of *Stenopterobia* and *Surirella* taxa (Bacillariophyceae) described from the insular Southeast Asia to the genus *Iconella*. Nova Hedwigia. Beiheft 147: 237–245. https://doi.org/10.1127/nova-suppl/2018/019

Kapustin DA, Kulikovskiy MS, Kociolek JP (2017) *Celebesia* gen. nov., a new cymbelloid diatom genus from the ancient Lake Matano (Sulawesi Island, Indonesia). Nova Hedwigia. Beiheft 146: 147–155. https://doi.org/10.1127/1438-9134/2017/147

Kapustin DA, Kociolek JP, Glushchenko AM, Kulikovskiy MS (2019) Four new species of *Cymbella* (Bacillariophyta) from the ancient Malili Lakes (Sulawesi Island, Indonesia). Botanicheskii Zhurnal 104(5): 766–780. https://doi.org/10.1134/S0006813619050065

Kapustin DA, Kociolek JP, Glushchenko AM, Kulikovskiy MS (2020) A rediscovery of *Cymbella mirabilis* Hustedt, a rare endemic diatom, and description of *Alveocymba* gen. nov. Diatom Research 35(3): 281–287. https://doi.org/10.1080/0269249X.2020.1772888

Kennedy B, Buckley Y, Allott N (2019) Taxonomy, ecology and analysis of type material of some small *Encyonopsis* with description of new species in Ireland. Phytotaxa 395(2): 89–128. https://doi.org/10.11646/phytotaxa.395.2.5

Kociolek JP (2018) A worldwide listing and biogeography of freshwater diatom genera: A phylogenetic perspective. Diatom Research 33(4): 509–534. https://doi.org/10.1080/0269249X.2019.1574243

Kociolek JP, Laslandes B, Bennett D, Thomas E, Brady M, Graeff C (2014) Diatoms of the United States 1. Taxonomy, ultrastructure and descriptions of new species and other rarely reported taxa from lake sediments in the Western U.S.A. Bibliotheca Diatomologica 61: 1–188.

Kociolek JP, Kapustin DA, Kulikovskiy MS (2018) A new, large species of *Gomphonema* Ehrenberg from ancient Lake Matano, Indonesia. Diatom Research 33(2): 241–250. https://doi.org/10.1080/0269249X.2018.1513868

Kociolek JP, Blanco S, Coste M, Ector L, Liu Y, Karthick B, Kulikovskiy M, Lundholm N, Ludwig T, Potapova M, Rimet F, Sabbe K, Sala S, Sar E, Taylor J, Van de Vijver B, Wetzel CE, Williams DM, Witkowski A, Witkowski J (2020) DiatomBase. http://www.diatombase.org/aphia.php?p=taxdetails&id=149565

Krammer K (1997a) Die cymbelloiden Diatomeen. Eine Monographie der weltweit bekannten Taxa. Teil 1. Allgemeines und *Encyonema* part. Biblioteca Diatomologica 36: 1–382.

Krammer K (1997b) Die cymbelloiden Diatomeen. Ein Monographie der weltweit bekannten Taxa. Teil 2. *Encyonema* part., *Encyonopsis* and *Cymbellopsis*. Bibliotheca Diatomologica 37: 1–463.

Krammer K (2003) *Cymbopleura*, *Delicata*, *Navicymbula*, *Gomphocymbellopsis*, *Afrocymbella*. In: Lange-Bertalot H (Ed.) Diatoms of Europe, Diatoms of the European Inland waters and comparable habitats. A.R.G. Gantner Verlag, Ruggell, 529 pp.

Kröger N (2007) Prescribing diatom morphology: Toward genetic engineering of biological nanomaterials. Current Opinion in Chemical Biology 11(6): 662–669. https://doi.org/10.1016/j.cbpa.2007.10.009

Kulikovskiy M, Kapustin D, Glushchenko A, Sidelev S, Maltsev Y, Gusev E, Kezlya E, Shkurina N, Kuznetsova I, Kociolek P (2020) Morphological and molecular investigation of *Gomphonema longissimum* and related taxa from Malili lakes (Indonesia) with comments on diatom evolution in ancient lakes. European Journal of Phycology 55(2): 147–161. https://doi.org/10.1080/09670262.2019.1664771

Le Cohu R, Gassiole G, Coste M (2014) Three new species of Cymbellales (Bacillariophyceae) from Réunion Island. Phytotaxa 156(3): 117–132. https://doi.org/10.11646/phytotaxa.156.3.3

Le Cohu R, Lange-Bertalot H, Van de Viver B, Tudesque L (2020) Analysis and critical evaluation of structural features in four Cymbellaceae taxa from New Caledonia. Fottea, Olomouc 20(1): 75–85. https://doi.org/10.5507/fot.2019.017

Levkov Z (2009) *Amphora* sensu lato. In: Lange-Bertalot H (Ed.) Diatoms of Europe. Diatoms of the European inland waters and comparable habitats (Vol. 5). A. R.G. Gantner Verlag, Ruggell, 916 pp.

Mark A, McKim S, Lowe RL, Kociolek JP (2019) Diatom community composition within *Ophrydium* colonies in northern Michigan, and the description of a new *Encyonopsis* Krammer species. Great Lakes Botanist 58: 210–221.

Marquardt GC, Da Rocha ACR, Wetzel CE, Ector L, Bicudo CEDM (2016) *Encyonema aquasedis* sp. nov. and *Kurtkrammeria salesopolensis* sp. nov.: two new freshwater diatom species (Cymbellales, Bacillariophyceae) from an oligotrophic reservoir in southeastern Brazil. Phytotaxa 247(1): 062–074. https://doi.org/10.11646/phytotaxa.247.1.4

Metzeltin D, Lange-Bertalot H (2002) Diatoms from the "Island Continent" Madagascar. In: Lange-Bertalot H (Ed.) Iconographia Diatomologica. Annotated Diatom Micrographs (Vol. 11). Taxonomy-Biogeography-Diversity. A.R.G. Gantner Verlag, Ruggell, 286 pp.

Metzeltin D, Lange-Bertalot H (2007) Tropical diatoms of South America II. Special remarks on biogeography disjunction. In: Lange-Bertalot H (Ed.) Iconographia Diatomologica. Annotated Diatom Micrographs (Vol. 18). Diversity-Taxonomy-Biogeography. A.R.G. Gantner Verlag K.G., Ruggell, 877 pp.

Moser G, Lange-Bertalot H, Metzeltin D (1998) Insel der Endemiten: Geobotanisches phänomen Neukaledonien. Bibliotheca Diatomologica 38: 1–464.

Potapova M (2014) *Encyonema appalachianum* (Bacillariophyta, Cymbellaceae), a new species from Western Pennsylvania, USA. Phytotaxa 184(2): 115–120. https://doi.org/10.11646/phytotaxa.184.2.4

Potapova M, Hamilton P, Kopyrina L, Sosina N (2014) New and rare diatom (Bacillariophyta) species from a mountain lake in Eastern Siberia. Phytotaxa 156(3): 100–116. https://doi.org/10.11646/phytotaxa.156.3.2

Vaillant J, Haffner GD, Cristescu ME (2011) The Ancient Lakes of Indonesia: Towards Integrated Research on Speciation. Integrative and Comparative Biology 51(4): 634–643. https://doi.org/10.1093/icb/icr101

Van de Vijver B, Verweij GL, Van der Wal J, Mertens A (2012) *Encyonopsis neerlandica*, a new freshwater diatom species (Bacillariophyta) from moorland pools in The Netherlands. Phytotaxa 66(1): 43–48. https://doi.org/10.11646/phytotaxa.66.1.7

von Rintelen T, von Rintelen K, Glaubrecht M, Schubart CD, Herder F (2012) Aquatic biodiversity hotspots in Wallacea: the species flocks in the ancient lakes of Sulawesi, Indonesia. In: Gower DJ (Ed.) Biotic Evolution and Environmental Change in Southeast Asia. Cambridge University Press, Cambridge, 290–315. https://doi.org/10.1017/CBO9780511735882.014

Wengrat S, Marquardt GC, Bicudo DDC, Bicudo CEDM, Wetzel CE, Ector L (2015) Type analysis of *Cymbella schubartii* and two new *Encyonopsis* species (Bacillariophyceae) from southeastern Brazil. Phytotaxa 221(3): 247–264. https://doi.org/10.11646/phytotaxa.221.3.3

Wydrzycka U, Lange-Bertalot H (2001) Las diatomeas (Bacillariophyceae) acidófilas del río Agrio y sitios vinculados con su cuenca, volcán Poás, Costa Rica. Brenesia 55–56: 1–68.

Zhang W, Gu X-W, Bao M-Y, Kociolek JP, Blanco S, Li Y-L ( (2020) *Kurtkrammeria tiancaiensis* sp. nov. a new cymbelloid species (Bacillariophyceae) from Lijiang Laojunshan National Park in Yunnan Province, China. Phytotaxa 451(3): 223–230. https://doi.org/10.11646/phytotaxa.451.3.5